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TESTING FOR CONCEPTS OF ECOLOGICAL SYSTEMS.

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PROVIDED FROM THE SCIENCE CONCEPT LEARNING PROJECT ARE (1) A PRETEST ON EQUILIBRIUM, AND (2) A POST-TEST OF KNOWLEDGE, COMPREHENSION, AND APPLICATION OF CONCEPTS OF ECOLOGICAL SYSTEMS. THE PRETEST (54 ITEMS) AND POST-TEST (60 ITEMS) ARE COMPOSED OF OBJECTIVE MULTIPLE-CHOICE ITEMS PREPARED FOR USE WITH JUNIOR HIGH SCHOOL STUDENTS. TEST AND ITEM STATISTICS ARE PROVIDED. THE TESTS WERE PREPARED FOR USE WITH A STUDY WHICH DETERMINED THE EFFECTIVENESS OF ADVANCED ORGANIZERS IN TEACHING SELECTED CONCEPTS OF ECOLOGICAL SYSTEMS AT THE JUNIOR HIGH SCHOOL LEVEL. THIS STUDY IS REPORTED IN TECHNICAL PAPER NO. 42 OF THE CENTER. (DS)

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TESTING FOR CONCEPTS OF ECOLOGICAL SYSTEMS

REPORT FROM THE SCIENCE CONCEPT LEARNING PROJECT

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RESEARCH
COGNITIVE
LEARNING
DEVELOPMENT

Practical Paper No. 3

TESTING FOR CONCEPTS OF ECOLOGICAL SYSTEMS

By Henry J. Triezenberg

Report from the Science Concept Learning Project
Milton O. Pella and George T. O'Hearn, Principal Investigators

Wisconsin Research and Development
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The University of Wisconsin
Madison, Wisconsin

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PREFACE

Contributing to an understanding of cognitive learning by children and youth—and improving related educational practices—is the goal of the Wisconsin R & D Center. Activities of the Center stem from three major research and development programs, one—Processes and Programs of Instruction—is directed toward the development of instructional programs based on research on teaching and learning and on the evaluation of concepts in subject fields. The staff of the science project, initiated in the first year of the Center, has developed and tested instructional programs dealing with major conceptual schemes in science to determine the level of understanding children of varying experience and ability can attain.

Found in this Practical Paper are: tests of the knowledge, comprehension, and application types related to the conceptual schemes of equilibrium and ecology. The tests are a part of a study conducted at junior high school level. The instructional procedure included the use of video tapes based upon concepts included within the two schemes. A brief description of the research is in the Introduction to this paper; Technical Report No. 42 of the Center carries full description of the study.

Herbert J. Klausmeier
Director

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INTRODUCTION

The tests in this working paper were constructed for utilization in the research that was reported in Technical Report No. 42 of the R & D Center entitled: The Use of an Advance Organizer in Teaching Selected Concepts of Ecological Systems. An abstract of this research follows.

ABSTRACT

The purpose of this study was to determine the relative effectiveness of three levels of abstraction (verbal, sketch, mechanical model) in the use of the conceptual scheme of equilibrium as an advance organizer applied to instruction with reference to ecological systems. Televised lessons were utilized to control classroom input for the instruction of pupils in Grades 7 and 9. The experimental design included a pretest, the teaching of nine lessons, and a posttest at three cognitive process levels: knowledge, comprehension, and application. Pupils were classified by grade and ability (low, average, and high ability based on IQ scores), and randomly assigned to treatment groups: verbal, sketch, and model.

The pretest was used to determine the pupils' knowledge of the conceptual scheme of equilibrium (the advance organizer) and their ability to apply it to ecological concepts. Treatment of the data utilizing the Analysis of Variance technique indicated that each of the differences between ability groups was significant but that the difference between the grades was not significant. The mean scores of pupils with average and high ability in both grades were equal to or greater than a minimum acceptable mean score of 15 percent above chance on the concept of static equilibrium. For these pupils the concept can serve as a useful introduction to the conceptual scheme of equilibrium. The mean scores of the following groups were equal to or greater than the minimum acceptable criterion on the specified ecological concepts: on three concepts of ecological equilibrium—only pupils of high ability in grade nine, on the concept of homeostasis—pupils of high ability in both grades, and on the concept of succession—none of the groups of pupils.

The posttest was used to determine the pupils' attainment of ecological concepts immediately after the termination of instruction and their retention of these concepts after six weeks. The data from both measures were treated by the Repeated Measures Analysis of Variance technique and, when appropriate, by the Newman-Keuls post hoc test. It was found that:

1. At the comprehension level the use of working models for reference to the organizer was significantly superior to verbal references or the use of sketches. There were no significant treatment differences at the knowledge or application levels.
2. In both grades the pupils of high ability earned significantly higher test scores than pupils of average ability and in grade nine pupils of average ability earned significantly higher test scores than pupils of low ability at the knowledge, comprehension, and application levels. In grade seven pupils of average ability earned significantly higher test scores than pupils of low ability only at the knowledge level. These results were not unexpected in view of the pretest results.
3. Significantly higher mean test scores were earned in grade nine than in grade seven at the knowledge level by all groups of pupils, at the comprehension level by pupils of high ability, and at the application level by pupils of high and average ability.
4. A significant decrease in mean scores earned by pupils in grade nine occurred at the knowledge level between the times when the posttest was given to measure attainment and when it was given to measure retention; a smaller but still significant

decrease occurred in both grades at the comprehension level, and no significant decrease occurred at the application level.

When the minimum acceptable criterion of 15 percent above chance was applied to the mean posttest scores earned by each grade-ability-treatment group on each concept, it was found that the following groups of pupils were successful on the specified concepts:

1. On the concept that "rates of opposing actions within ecological factors are related to conditions of dynamic equilibrium in the system," pupils of average ability in grade nine succeeded when the teaching method utilized sketches or models; pupils of average ability in grade seven succeeded when the method utilized sketches; and pupils of high ability in grades seven and nine succeeded when the method utilized any one of the three procedures.
2. On the concept that "rates of absorption and release of matter and energy (the abiotic factors of an environment) by populations are related to a condition of dynamic equilibrium within limits of tolerance for the system," pupils of average ability in grade nine succeeded when the teaching method utilized the sketch or model treatment, and pupils of high ability in both grades succeeded when the method utilized any one of three procedures.
3. On the concept that "populations exist in dynamic equilibrium conditions when the rates of birth and death are equal," pupils of average ability in grade nine succeeded when the teaching method utilized verbal references to the conceptual scheme of equilibrium and pupils of high ability in both grades succeeded when the method utilized any one of the three procedures.
4. On the concept that "succession is a sequence of events within an ecosystem that has a predictable pattern of community changes disrupting an equilibrium condition over time which may be related to the presence of organisms and to cultural changes," pupils of average ability in grade nine and pupils of high ability in grade seven succeeded when the teaching method utilized models, and pupils of high ability in grade nine succeeded when the method utilized any one of the three procedures.

A survey of attitudes indicated that the pupils considered the lessons interesting, enjoyable, and educational, but quite difficult. The rank order of treatment groups in a comparison from the highest to the lowest positive attitude of pupils was: model, sketch, verbal.

TEST ADMINISTRATION

A classroom teacher read the test directions to the pupils before administering each test. Pupils were then requested to answer the two sample questions to insure uniformity in their utilization of Digitek answer sheets. The tests were designed as power tests to be completed well within the limits of a 45-minute class period.

TEST AND ITEM STATISTICS

Test statistics presented in this working paper are the mean scores ($\bar{X}$), the standard deviations (s), and the internal consistency reliabilities of the tests computed by means of Hoyt's Analysis of Variance Method (R). The test statistics were computed from the scores achieved by 270 pupils randomly sampled from a population of pupils in Grades 7 and 9 with low, average, and high ability. The concept numbers refer to the following concepts.

I. The magnitudes of forces acting in opposing directions are related to a condition of static equilibrium within the limits of tolerance for the system.
II. Rates of opposing actions within ecological factors are related to conditions of dynamic equilibrium in the system.
III. Rates of absorption and release of matter and energy (the abiotic factors of an environment) by populations are related to a condition of dynamic equilibrium within limits of tolerance for the system.
IV. Populations exist in dynamic equilibrium conditions when the rates of birth and death are equal.
V. Homeostasis is the self-regulating adjustment of several interacting relationships in a system tending toward a steady-state dynamic equilibrium.
VI. Succession is a sequence of events within an ecosystem that has a predictable pattern of community changes disrupting an equilibrium condition over time which may be related to the presence of organisms and to cultural changes.

The pretest consisted of nine items for each of the six concepts. Posttest items were

equally distributed among knowledge, comprehension, and application cognitive process levels, and the number of items related to each ecological concept corresponded roughly to the proportion of time used to teach that concept (concept II—15 items, II—18, IV—12, V—3, VI—12). The posttest item statistics included in this report are the proportion of the pupils who chose each possible response with the correct response underlined (traditional item difficulty), the X_{50} (the placement on the test achievement scale of the median item score), and β (a measure of the degree to which the item discriminates between high and low achieving pupils). Correct responses are also indicated by underlining the appropriate letter on the test copies in this report.

TEST DIRECTIONS

Do not write or mark on this test booklet. Clearly print your name and the date on the answer sheet.

Like most tests, this test is designed to help you find out how much you learned from the lessons. Unlike most tests, many questions in this test are designed to determine whether or not you can use the ideas presented in the lessons in new situations. Therefore, many of the situations will be new to you. Try to figure out the answer by using the *ideas* you have learned in these lessons *or* in your past experience.

Answer each question by placing a pencil-mark in the correct space on the answer sheet that corresponds with the choice that you select as correct. For each question there is *one best* answer; you are to choose the best answer. Use pencil only, making each mark completely fill the space. If you must erase, do so completely and leave no stray marks. Answer each question like the following sample question is answered.

160. Each of us lives in a definite geographic area on earth. You live in

A. South America.
B. Michigan.
C. Canada.
D. Wisconsin.

Now answer the next question for practice.

161. In the community (city or town) where you go to school, people can live together by performing special kinds of work. A kind of worker you would expect to find in your community is a(n)

A. School teacher.
B. Orange grower.
C. Lobster trapper.
D. Astronaut.

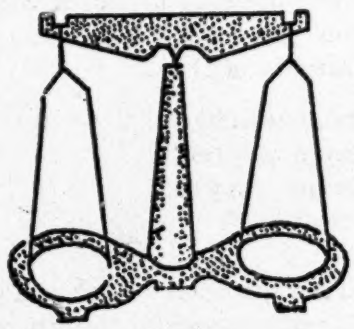
If you filled the space with the (A) for question 161, you answered the question correctly.

Wait until your teacher tells you to turn the page.

PRETEST

1. A *static* equilibrium condition may exist when

   A. the rates of fish migration into and out of an ecosystem are equal.
   B. the rates of fish migration into and out of an ecosystem are unequal.
   C. the weights on the two pans of a balance are equal.
   D. the weights on the two pans of a balance are unequal.



2. An equal arm balance like that shown, is in a condition of equilibrium when there are equal weights on both pans. How could you remove some weights and still maintain a condition of equilibrium?

   A. Remove half of the weights from pan A.
   B. Remove half of the weights from both pan A and pan B.
   C. Remove one-fourth of the weights from pan B.
   D. Remove all of the weights from pan A.

3. An equal arm balance like that shown in question 2 is in a condition of equilibrium when there are equal weights on both pans. How could you destroy the condition of equilibrium?

   A. Add weights smaller than the limit of tolerance on pan A.
   B. Add weights larger than the limit of tolerance on pan A.
   C. Add the same weights that are larger than the limit of tolerance to both pan A and pan B.
   D. Add the same weights that are smaller than the limit of tolerance to both pan A and pan B.

4. In an equilibrium condition the interacting forces are in balance. Equilibrium conditions exist

   A. over time in an oscillating balance system.
   B. in a balance system with one pan up and the other pan down, touching the stand.
   C. between an accelerating car and forces due to friction.
   D. between forces due to gravity acting on a football thrown into the air and forces due to friction.

5. How can you disturb the state of equilibrium of a balance with limits of tolerance of .2 grams?

   A. Add a 10 gram-weight to each pan.
   B. Add two 10 gram-weights to pan A and one 10 gram-weight to pan B.
   C. Add two 10 gram-weights to both pan A and pan B.
   D. Add three 10 gram-weights to each pan.

6. A balance is in an equilibrium condition when there are 40 gram-weights on each pan. When you add .2 gram-weight to pan B it remains in equilibrium but when you add .3 gram-weight to pan B, the equilibrium condition is disturbed. How could you cause the balance to return to a state of equilibrium?

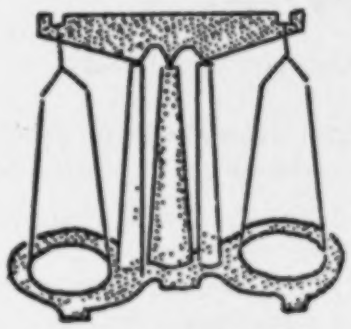
   A. Add .4 gram-weights to pan B.
   B. Add .8 gram-weights to pan A.
   C. Remove .4 gram-weights from pan B.
   D. Remove .8 gram-weights from pan A.

7. An equilibrium condition does not exist in

   A. an equal tug-of-war contest.
   B. a book at rest on a table.
   C. in a weight hanging from a spring.
   D. a ball falling through the air.

8. Two boys push against each other with their hands. An equilibrium condition exists when they push

   A. with equal forces and in opposite directions.
   B. with unequal forces and in opposite directions.
   C. with unequal forces and in the same directions.
   D. with equal forces and in the same directions.



9. Additional supports are placed under the beam of a balance on both sides of the center of rotation as illustrated. What effect would the additional supports have on the limits of tolerance for a condition of equilibrium?

   A. The limits would be increased.
   B. The limits would be decreased.
   C. The limits would not change.
   D. The system could never be in a condition of equilibrium within the limits of tolerance.

10. A condition of dynamic equilibrium does *not* exist directly between

    A. interacting processes in an ecosystem.
    B. rates of evaporation and condensation.
    C. wind and the number of plants in an ecosystem.
    D. rates of fish migration into and out of an ecosystem.

11. Less water is available for plant growth in southern than in northern Wisconsin. This difference is *not* related to

    A. increased wind in the southern part of the state.
    B. increased evaporation stress in the southern part of the state.
    C. increased solar energy in the southern part of the state.
    D. decreased humidity in the southern part of the state.

12. Liquid water in a system is in an equilibrium condition with water in the gas phase. What relationships exist in the system?

    A. The amount of liquid water equals the amount of water gas.
    B. The rate of heat energy absorption by the liquid equals the rate of heat energy loss by the gas.
    C. The rate of evaporation equals the rate of solution.
    D. The rate of molecular motion of the liquid equals the rate of molecular motion of the gas.

13. A condition of dynamic equilibrium exists within an ecosystem. Which of the following pairs of changes within the ecosystem will occur together when no other factors are changed?

    A. A greater rate of evaporation with a smaller rate of condensation.
    B. A greater velocity of the wind with a greater density of plants in a population.
    C. More ducks migrate into the ecosystem than migrate out of it.
    D. A larger birth rate of fish with a larger death rate.

14. Within a certain system an equilibrium condition exists between the liquid and gas phases of water. Which of the following changes would occur together in this system?

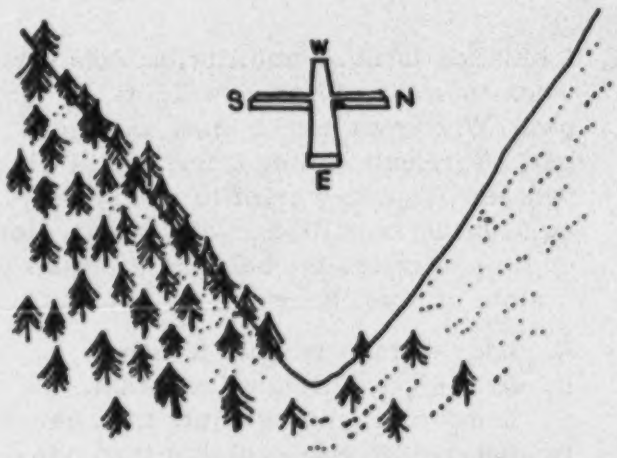
A. Higher wind velocities with lower evaporation stress.
B. A larger amount of water vapor in the air with a lower evaporation stress.
C. A larger amount of water vapor in the air with a higher evaporation stress.
D. A higher rate of heat energy loss by the water vapor with more evaporation stress.

15. In a condition of dynamic equilibrium, the processes or rates of opposing changes in factors are about equal. Considering the earth as an ecosystem in such a condition with reference to water,

A. the average rate of evaporation of water equals the average rate of erosion by water.
B. the *number* of water molecules in the vapor phase equals the number in the liquid phase.
C. the average rate of evaporation of water equals the average rate of condensation of water.
D. the rate of condensation of water exceeds the rate of evaporation.

16. A dynamic equilibrium condition exists in the soil ecosystem of a forest floor. Which of the following relationships would exist in such a system?

A. The amount of dead plant and animal material on the forest floor would remain steady.
B. The amount of dead plant and animal material on the forest floor would increase.
C. The populations of earthworms and soil insects would decrease as the populations of fungi (molds) and bacteria increased.
D. The population of earthworms and soil insects would increase as the population of fungi (molds) and bacteria decreased.



17. A valley is formed by mountains and it extends from the east toward the west. The mountain on the north side of the valley faces south—the predominant direction from which solar rays come. This mountain on the north side supports a few trees near the bottom and is covered with grass. The other mountain, that faces north, is covered with trees. How are these differences in the nature of the plant populations explained?

A. The north-facing mountain has greater evaporation stress than the south-facing mountain.
B. Water runs off both mountains so they are equally dry.
C. The south-facing slope has greater evaporation stress than the north-facing slope.
D. Water evaporates from both mountains so they are equally dry.

18. The evaporation stress on a north- or south-facing slope is related to

A. the increased carbon dioxide in the air over one slope.
B. the increased humidity since there is more evaporation from one slope.
C. the decreased wind as the heated air expands and rises over a slope.
D. the increased concentration of solar rays striking on the slope.

19. The abiotic factors of any ecosystem do *not* include

A. water.
B. heat.
C. frogs.
D. oxygen.

20. Plant communities change in a general way from dense forests in western United States to deserts east of the mountains, from there to grasslands farther east and then to deciduous forests in eastern United States. These changes are *not* related to

A. changes in rainfall.
B. changes in solar energy input.
C. limits of tolerance for the water factor by a kind of plant population.
D. changes in animal communities.

21. Plant communities change in a general way from coniferous forests in Canada, to deciduous forests in the United States, to the tropical rain forests of the Caribbean Islands and Central America. These changes from north to south in the northern hemisphere are related to the limiting factor of

A. rainfall.
B. solar energy input.
C. limits of tolerance for the water factor by a kind of plant population.
D. animal communities.

22. Generally there are more layers in a tropical forest than in a temperate forest. In a Mexican rain forest you would expect to find

A. a smaller diversity of populations.
B. a lower relative humidity near the forest floor.
C. a greater amount of light reaching the forest floor.
D. a greater diversity of microclimates.

23. Imagine an ecosystem in which the dominant population is trees with broad leaves and the limiting factor is solar energy. An increase in solar energy input is related to

A. an increase in biomass.
B. a decrease in biomass.
C. an increase in the rate of condensation at the forest floor.
D. a decrease in the rate of evaporation from the tree leaves.

24. Energy is absorbed by an ecosystem as

A. water changes from the liquid to the vapor state.
B. radiant energy is changed to heat energy as it strikes the earth.
C. carbon dioxide and water are combined in the green plant to form oxygen and sugar.
D. all of these processes occur.

25. You would be more likely to find the following situation in a Mexican rain forest than in a Canadian coniferous forest.

A. Limiting factors for plant growth are solar energy and water.
B. Limiting factors for plant growth are carbon dioxide and soil nutrients.
C. Populations of lynx are living within their limits of tolerance.
D. More carbon dioxide molecules near the forest floor mix with the air by wind than by their own energy of motion.

26. In the lowlands of Mexico it is more likely than in the lowlands of northern United States that

A. areas with small amounts of available water will be desertlike.
B. forest ecosystems will have a greater diversity of populations.
C. water will not be available for much of the year because it is in the solid phase.
D. molecules that make up water, air, and soil have less energy of motion.

27. A rain forest may be found near the Mexican coast. If you climb a nearby mountain you find a deciduous forest part way up and a coniferous forest farther up the mountain as illustrated. Ecosystems at higher altitudes have

A. more biomass.
B. less solar energy striking them.
C. a greater diversity of populations.
D. a greater loss of the solar energy striking them.

28. The population in an ecosystem may be described as

A. the lynx that were trapped in an area.
B. all the plants and animals in an area.
C. one of the frogs in an area.
<u>D.</u> a group of organisms of any one kind in an area.

29. In the energy transfer from a dragonfly population to a frog population, how much of the energy is lost to the abiotic environment as heat?

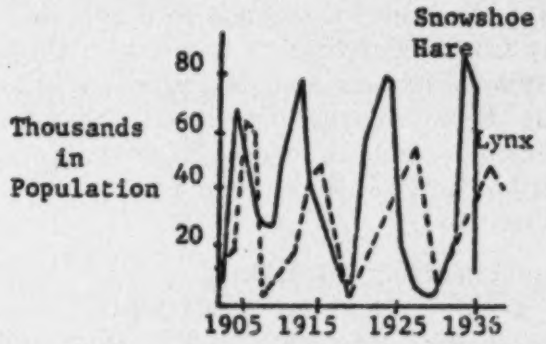
A. roughly one-tenth.
<u>B.</u> roughly nine-tenths.
C. roughly one-half.
D. none of the energy is simply lost by the community: it is all destroyed.

30. In the lynx-snowshoe hare interaction, the population of predators and prey are in a condition of equilibrium over time.

A. The number of lynx equals the number of hares.
B. The amount of biomass in the lynx population is about equal to that of the hare population.
C. The amount of chemical energy in the lynx population is about equal to that of the hare population.
<u>D.</u> The size of the lynx population at any one time is about the same as it will be about 9 or 10 years later.

31. Lynx and rabbit populations are in a condition of equilibrium over time. This means that

A. for each lynx born, a lynx dies that year.
B. for each lynx born, a hare dies that year.
<u>C.</u> for each lynx born, a lynx dies when averaged over several years.
D. for each lynx born, many lynx die when averaged over several years.



32. According to the graph, in 1925

A. the population of hares is increasing and the population of lynx is decreasing.
<u>B.</u> the population of hares is decreasing and the population of lynx is increasing.
C. both populations of hares and lynx are increasing.
D. both populations of hares and lynx are decreasing.

33. Suppose that in the hare-lynx ecosystem, good nesting sites and other favorable conditions were provided for populations of owls and hawks. What would be the effect on the periodic oscillations indicated by the graph?

<u>A.</u> The peaks of the graph lines would be lower.
B. The peaks of the graph lines would be higher.
C. The period of time for an oscillation would be less than 9 or 10 years.
D. The period of time for an oscillation would be greater than 9 or 10 years.

The following statement will help you answer questions 34, 35, and 36. Suppose you find an ecosystem in which you see deer, caterpillars, and aphids (tiny insects) eating green plants. You also see aphid lions and lady beetles eating aphids: birds eating insects, and wolves eating rabbits. You also notice fungi (molds and mushrooms) growing on food stored in dead plant material, and bears eating berries and fish.

34. Some first order consumers in this system include

A. wolves, aphid lions, and birds.
B. lady beetles, birds, and bear.
<u>C.</u> deer, bear, and fungi.
D. green plants, birds, and bear.

35. Some second (or higher) order consumers in the system described above include

A. aphids, mushrooms, and bear.
B. wolves, birds, and bear.
C. deer, caterpillars, and green plants.
D. deer, caterpillars, and bear.

36. Suppose the population of insect-eating birds suddenly became very large one spring. What would you expect to happen to other populations in the system that year?

A. The populations of insects would decrease.
B. The populations of insects would increase.
C. The populations of insects would not change.
D. The populations of plants would decrease.

37. Homeostasis is

A. the tendency of several interacting relationships in a system to go out of equilibrium.
B. a static condition of equality between or among interacting processes in a system.
C. the self-regulating adjustment of several interacting relationships in a system, tending toward a dynamic equilibrium.
D. the self-regulating adjustment of a single relationship in a system, tending toward a dynamic equilibrium.

38. The homeostatic mechanism of control of the hare population in an ecosystem directly involves

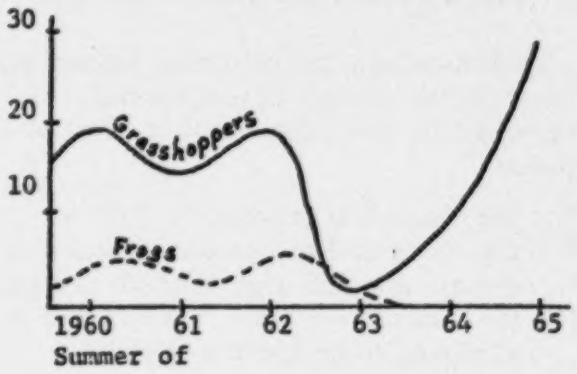
A. the number of hiding places available for the hares.
B. the number of lynx around to catch them.
C. the size of the plant population available as food to the hare population.
D. all of these factors.

39. As a thermostatic strip is heated, it bends in one direction and turns on an air conditioner which then removes heat from a room. Likewise, in the process of homeostasis, as the population of hares increases,

A. the population of plants they need for food and protection increases also.
B. the increase lags behind a similar increase in the lynx population.
C. they destroy their own food and protection and thus decrease their population.
D. all of these processes.

40. In the food chain—grass, grasshopper, frog, snake, and hawk—a homeostatic relationship could exist between populations of

A. grass and grasshoppers.
B. grass, grasshoppers, and frogs.
C. frogs and snakes.
D. snakes and hawks.



41. The above graph indicates that

A. a condition of dynamic equilibrium exists between populations of grasshoppers and frogs from 1960 to 1962.
B. a homeostatic mechanism operates between populations of grasshoppers and frogs.
C. the population of grasshoppers increases considerably from 1962 to 1963.
D. the population of grasshoppers decreases considerably from 1963 to 1965.

42. A homeostatic mechanism of population control will not work when

A. one of the interacting populations decreases past its tolerance limits.
B. one of the interacting populations increases past its tolerance limits.
C. one of the equilibrium conditions involved is destroyed.
D. all of the above processes.

43. A homeostatic relationship in the food chain: birds, insects, and plants does *not* imply that

A. if the bird populations are killed the insect-plant relationship would still be controlled.
B. the population of insects may control itself by eating its own protective hiding place.
C. the population of insects may control the population of birds.
D. the insect-plant and the bird-insect relationships provide the control.

44. A growth-regulating chemical called auxin controls the growth of plant roots. A homeostatic mechanism could exist between

A. the auxin and gravity.
B. the auxin and the growth of plant roots.
C. gravity and the growth of plant roots.
D. the auxin-to-gravity relation and the auxin-to-plant growth relation.

45. Aspen trees grow well along the wet shorelines of ponds and rivers. Beavers use aspen trees for food and to build dams and shelters. A homeostatic relationship could exist between

A. aspen trees and the shoreline of a pond.
B. the beaver activity and the level of the pond.
C. both of the above relations.
D. none of the above relations.

46. An ecosystem is *not*

A. a space or area in which living and nonliving factors interact in distinctive relationships.
B. a living community with its nonliving factors and relations among them.
C. a system of distinctively related biotic and abiotic factors.
D. a space or area in which each kind of plant and animal lives independently of all other plants and animals.

47. Biological succession occurs when

A. living things change their abiotic environment.
B. populations in an ecosystem maintain a condition of equilibrium over time.
C. an organism dies and a new organism in the same population succeeds it.
D. the chemical energy of one population is used by the next population for food.

48. Succession of populations in a pond ecosystem is related to

A. changes in the water factor.
B. changes in the soil nutrient factor.
C. both of these factors.
D. neither of these factors.

49. Prairie plants store a greater proportion of their food in their roots than do the deciduous trees. Prairie plants also produce few seeds and a thick mat of dead plant material if *not* burned every couple of years. These characteristics mean that

A. burning a prairie will destroy the equilibrium condition of its producers.
B. burning a prairie helps maintain the equilibrium condition of its producers.
C. more moisture is stored in a burned prairie than in an unburned prairie.
D. a deciduous forest will succeed a prairie that is burned periodically.

50. Southern Wisconsin receives enough annual rainfall and has other conditions appropriate for a deciduous forest ecosystem yet during historic times it was largely a prairie grassland. During the time the area was periodically burned, much of the prairie grassland

A. did not go through succession to a forest.
B. did not maintain a condition of equilibrium.
C. did go through succession to a forest.
D. first order consumers like grasshoppers, were succeeded by populations of forest consumers.

51. When people stopped burning the prairie grassland every couple of years,

A. the accumulation of dead grass soaked up water, making it available in dry seasons.
B. the soil was too poor to grow deciduous trees.
C. both of these conditions.
D. none of these conditions.

52. Termites, ants, and other insects make tunnels in the wood of a dead tree. In the process they carry bacteria and fungi (mold, mushroom) spores, and moisture into the tunnels. Gradually the amount of available moisture in the log increases and

A. may exceed the limits of tolerance for the termite and ant populations, decreasing these populations.
B. provides favorable conditions for the growth of bacteria and fungi.
C. the chemical energy stored in the log decreases.
D. all of the above processes.

53. Processes that occur over a long period of time in a rotting log are called

A. succession.
B. association.
C. equilibrium.
D. homeostasis.

54. Men increase the rate of succession in a pond ecosystem when they

A. keep a plant cover on the surrounding land.
B. treat sewage thoroughly before washing it into the pond.
C. permit organic matter to wash into the pond.
D. remove the excess growth of water plants regularly.

POSTTEST

1. A direct equilibrium relationship may exist between

   A. available water and plant biomass.
   B. evaporation and condensation of water.
   C. drainage of water into and out of an ecosystem.
   D. the factors in each of the above choices.

2. The evaporation stress in an ecosystem increases as the

   A. relative humidity decreases.
   B. wind decreases.
   C. temperature decreases.
   D. number of rainy days each year increases.

3. The canopy of the trees in a forest aids in the accumulation of carbon dioxide near the forest floor by

   A. causing it to be absorbed in water.
   B. preventing the wind from blowing it away.
   C. preventing the carbon dioxide molecules from mixing with the air by their own energy of motion.
   D. absorbing it in photosynthesis.

4. Solar energy is absorbed by an ecosystem in all of the following processes except

   A. photosynthesis.
   B. evaporation.
   C. reflection.
   D. transformation of radiant energy to heat energy upon striking the earth.

5. Energy is absorbed by an ecosystem as

   A. water molecules change from the vapor to the liquid phase.
   B. heat energy is transformed to radiant energy at the surface of the earth.
   C. water molecules change from the liquid to the vapor phase.
   D. radiant energy is reflected from the atmosphere and from the earth surface.

6. A condition of dynamic equilibrium exists within an ecosystem. Which of the following pairs of changes within the ecosystem will occur together when no other factors are changed?

   A. A smaller supply of available water with a more luxuriant plant growth.
   B. A smaller supply of available water with a greater rate of drainage.
   C. A lower rate of evaporation with a greater rate of condensation.
   D. A lower rate of evaporation with a greater velocity of the wind.

7. Suppose that in an ecosystem the evaporation of water is in equilibrium with the condensation of water. Which of the following changes in conditions will cause an increase in evaporation stress?

   A. An increase in water vapor in the air.
   B. A decrease in temperature.
   C. A decrease in wind velocity.
   D. A decrease in the number of rainy days per year.

8. The average sizes of the particles making up the soil varies from one ecosystem to another. In those systems where the soil particles are large when compared to other systems, it is likely that the concentration of soluble minerals in the upper layers of soil will be

   A. high.
   B. low.
   C. the same.
   D. non-existent.

9. An ecosystem on a Caribbean island near the equator receives more solar energy input than a system in Newfoundland in the north because the solar rays near the equator usually

A. travel a greater distance through the atmosphere than in the north.
B. are concentrated on a smaller area than in the north.
C. are available for less time each day than in the north.
D. are related to this ecosystem in all of the above ways.

10. If a rain forest on a Caribbean island is considered to be an ecosystem in a condition of equilibrium with reference to water

A. the average rate of evaporation of water equals the average rate of erosion by water.
B. the average rate of evaporation of water equals the average rate of condensation and rainfall.
C. the average rate of evaporation equals the average rate of drainage of water.
D. the number of water molecules in the form of vapor in its atmosphere equals the number of water molecules in the liquid state in its lakes and streams.

11. Valley A is located on a Caribbean island near the equator. Valley B is located in Newfoundland in the north. Both valleys extend from east to west so they have north- and south-facing slopes. On which slope would the evaporation stress be greater than on its opposing slope?

A. South-facing slope in Newfoundland.
B. South-facing slope on the Caribbean island.
C. North-facing slope on the Caribbean island.
D. Same on all slopes.

12. Northwestern Wisconsin has sandy soil and northeastern Wisconsin has soil with more clay and humus. When these two soil type areas are compared it is expected that

A. the sandy soil will retain more water in the upper layers than the clay-humus soil.
B. the sandy soil will contain a larger amount of soluble minerals in the upper layers than the clay-humus soil.
C. the rate of water drainage through the sandy soil will be greater than the rate of drainage through clay-humus soil.
D. the rate of evaporation from the surface of the sandy soil will be greater than the rate of evaporation from the clay-humus soil.

13. The abiotic factors of any ecosystem include

A. carbon dioxide.
B. alligators.
C. bacteria.
D. humus.

14. Suppose a fern on the forest floor has a small amount of carbon dioxide available, but has a sufficient amount of light energy, water, and soil nutrients. Then the carbon dioxide

A. limits the activity of animals.
B. concentration increases in the daytime when a large amount of solar energy is available.
C. concentration in the air increases when plant growth increases.
D. is the limiting factor in the growth of green plants.

15. Northern hemlock-hardwood forests extend southward on the mountain ranges of the United States. This type of forest growth on these mountain ranges is related primarily to the limiting factor of

A. water.
B. solar energy.
C. soil.
D. animal communities.

16. Organisms that make up a plant population that is predominant in the desert would likely have one or more of the following types of structures except

A. large leaf surface areas.
B. large root areas.
C. thick, fleshy stems.
D. leaves that are deciduous in the dry season.

17. The rate of photosynthetic activity in an ecosystem increases when all other conditions remain optimum but the

A. temperature decreases from 70°F to 32°F.
B. annual rainfall decreases from 50 inches to 5 inches.
C. intensity of the green light is increased.
D. amount of available carbon dioxide is increased from .03% to .3%.

18. Different layers of the decidous forest in the summer have different microclimates. Going down from the upper leaves in the canopy you would expect to find microclimates with increasing

A. solar energy.
B. temperature.
C. light.
D. relative humidity.

19. Some plants have special growth patterns adapted to very rapid growth and flowering when they are given plenty of solar energy and water. Such organisms are likely to be found

A. in the deciduous forest in spring.
B. in the coniferous forest in winter.
C. in the grasslands in summer.
D. in the rain forest in the rainy season.

20. The amount of energy in an ecosystem is increased when

A. consumers eat producers.
B. consumers eat other consumers.
C. photosynthesis produces sugar.
D. all of the above processes occur.

21. Carbon dioxide in the air is in a condition of equilibrium with a living community when

A. it is used by animals in respiration as fast as it is given to the air by plants in photosynthesis.
B. it is used by plants in photosynthesis as fast as it is given to the air by animals in respiration.
C. it is used by plants in photosynthesis as fast as it is given to the air by plants *and* animals in respiration.
D. it is blown out of a community by the wind as rapidly as it is given to the air by plants *and* animals in respiration.

22. A rancher would be following good ecological principles and promoting conditions of stable equilibrium for the water factor in a watershed by

A. grazing cattle on the stream banks.
B. building artificial ponds.
C. permitting soil to erode.
D. digging ravines and gullies for more rapid drainage.

23. In which of the following ecosystems would you be likely to find the greatest diversity of populations?

A. A tamarack swamp in Wisconsin.
B. A maple-birch forest in Wisconsin.
C. A tropical rain forest in a Caribbean island.
D. A desert in Nevada.

24. The factors most likely limiting plant growth in a Caribbean rain forest are

A. carbon dioxide and soil nutrients.
B. solar energy and water.
C. solar energy and soil nutrients.
D. first-order consumers.

25. The humus part of the soil

A. is composed of living organisms and their waste products.
B. is composed of organic matter being decomposed by scavengers, fungi, and bacteria.
C. allows water to drain rapidly through, carrying dissolved minerals with it.
D. helps speed up the erosion of soil by wind and water.

26. Mineral salts are transported through the soil by all of the following processes *except*

A. precipitation and crystallization as water evaporates from the soil surface.
B. solution and drainage between the soil particles.
C. diffusion through the soil solution from places where the salt is less concentrated to places where the salt is more concentrated.
D. diffusion through the soil solution from places where the salt is more concentrated to places where the salt is less concentrated.

27. The pine trees in the southeastern United States are of the type found in dry ecosystems. This is related primarily to

A. a low annual rainfall.
B. a high evaporation stress.
C. a high rate of drainage through sandy soil.
D. a low rate of drainage through sandy soil.

28. Plant roots grow down into the soil in response to

A. the tendency to seek water.
B. a homeostatic mechanism between the gravity-auxin relation and the auxin-plant growth relation.
C. a homeostatic mechanism between the light-auxin relation and the auxin-plant growth relation.
D. its tendency to establish an equilibrium condition between the plant root and gravity.

29. Minerals may become available to plants in an ecosystem by all of the following processes except

A. the decomposition of dead organic matter.
B. the breaking up of rocks through freezing of water or growth of seeds.
C. the solution of minerals by water.
D. the precipitation and crystallization of minerals.

30. Mineral salts tend to collect in places where there is poor drainage and where there is a high rate of evaporation. Halophyte plants can grow here when water molecules pass through a semi-permeable membrane to the

A. inside of the roots where water molecules are more concentrated.
B. inside of the roots where mineral particles are more concentrated.
C. outside of the roots where water molecules are more concentrated.
D. outside of the roots where mineral particles are more concentrated.

31. The average size of the particles making up the soil varies from one ecosystem to another. In those systems where the soil particles are large when compared to other systems, one expects to find a larger portion of

A. xerophytic plants.
B. mesophytic plants.
C. hydrophytic plants.
D. halophytic plants.

32. A tree on a stream bank falls and leans over the stream and soon grows upwards again. A homeostatic relationship could exist between

A. the stream and the tree growth.
B. gravity and the tree growth.
C. light and the tree growth.
D. gravity, auxin, and the tree growth.

33. Nitrate mineral salts may become available to plants in an agricultural ecosystem by all of the following processes except

A. the growth of leguminous plants like peas and soybeans with their nitrogen-fixing bacteria.
B. the decomposition of proteins and the action of nitrifying bacteria.
C. the application of potassium nitrate mineral salts to the soil surface.
D. the erosion of soil without plant cover.

34. Compared to the cells of an organism living in a freshwater lake, the cells of a similar organism living in a saltwater ocean are likely to have a higher concentration of

A. sugar.
B. water.
C. mineral salts.
D. decomposed food.

35. Pine trees found growing in northwestern Wisconsin are of the type found in dry ecosystems. Knowing that the rainfall is about the same as in neighboring areas you would expect

A. smaller mineral particles in the soil.
B. larger mineral particles in the soil.
C. more humus in the soil.
D. more clay in the soil.

36. The leaves on a plant follow the sun, facing the sun as its position in the sky changes throughout the day. This could be in response to

A. a homeostatic mechanism between the sunlight auxin relation and the auxin-plant growth relation.
B. a homeostatic mechanism between the gravity-auxin relation and the auxin-plant growth relation.
C. its tendency to establish an equilibrium condition between the sunlight and plant growth.
D. its tendency to establish an equilibrium condition between gravity and plant growth.

37. Which of the following groups in an ecosystem has the smaller biomass?

A. Producers.
B. First-order consumers.
C. Third-order consumers.
D. Fifth-order consumers.

38. Populations in an ecosystem that are associated in the same space at the same time but with no energy transferred between them may

A. be populations of lynx and snowshoe hares.
B. be populations of gophers and hawks.
C. have the same abiotic requirements.
D. have the same biotic *or* abiotic requirements.

39. An example of a commensal association is

A. the whale-barnacle association.
B. the alga-fungus association in lichens.
C. the legume (peas, beans, etc.) and nitrogen-fixing bacteria association in root nodules.
D. the lynx-hare association.

40. When a condition of equilibrium occurs in a population of wood ducks over time, on the average each pair of ducks can raise to maturity

A. one of its young.
B. two of its young.
C. six of its young.
D. eight of its young.

41. The rate of death of biomass in a system is about equal to the rate of decay of organic matter in all of the following situations ***except*** when

A. the amount of humus is steady over time.
B. the population of decomposers is steady over time.
C. the ecosystem is in a condition of equilibrium.
D. the ecosystem is going through the process of succession.

42. Populations in an ecosystem that are associated in space, time, and energy transfer include all of the following pairs ***except***

A. flies and dead rabbits.
B. foxes and ducks.
C. maple and birch trees.
D. mistletoe plants and oak trees.

43. In a condition of equilibrium over time, the energy gained by a population is equal to the total energy that

A. is transferred to the populations of its consumers.
B. is transferred to its decomposers.
C. is transformed to heat energy.
D. is transferred or transformed to all the above.

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44. An increase in the population of wood ducks in an ecosystem would likely be followed by

A. a decrease in the populations of decomposers.
B. a decrease in the populations of duck parasites.
C. an increase in the populations of mallard ducks.
D. an increase in the populations of snapping turtles, foxes, and hawks.

45. As you move from a Canadian coniferous forest to a Caribbean rain forest you would be likely to find

A. an increase in the available minerals.
B. an increase in the rate of decomposition.
C. an increase in the amount of humus.
D. a decrease in the populations of soil micro-organisms.

46. Where would you expect to find an ecosystem with the most stable condition of equilibrium among its populations?

A. In the rain forest on a Caribbean island.
B. In the grassland of the United States' prairie.
C. In a Canadian coniferous forest.
D. In a Nevada desert.

47. The remora is a small fish with a suction disk on the top of its head, by which it attaches itself to sharks. The effect on the shark is neutral but the remora benefits from free transportation and food supply (the un-eaten remains of the shark's prey). This is an example of

A. parasitism.
B. predator-prey.
C. commensalism.
D. mutualism.

48. Consider a partial food web in an ecosystem where wood ducks grow to maturity. The producer, first-order consumer, and second-order consumer are, in that order,

A. duckweed in pond, fox, wood duck.
B. wood duck, turtle, duckweed.
C. duckweed, wood duck, fox.
D. duckweed, duck-hawk (Peregrine falcon), fox.

49. All of the following events are characteristic of successive communities associated over time *except*

A. enrichment of the soil by humus in a steady state.
B. enrichment of the soil by an increasing amount of humus.
C. shading by the canopy and understory.
D. providing protection from weather and predators.

50. The succession from sand dunes to forests proceeds in the following order:

A. cottonwoods and digger wasps to sand grass and wolf spiders.
B. pine trees and deer to cottonwoods and digger wasps.
C. oak trees and earthworms to pine trees and deer.
D. sand grass and wolf spiders to maple trees and snails.

51. Certain grasslands in Australia produced food for large herds of cattle. When rabbits were introduced into the ecosystem but not rabbit predators,

A. the populations of cattle increased.
B. the biomass production of the grasses increased.
C. the populations of rabbits increased to the limits of their food supply.
D. the overall diversity of the ecosystem increased.

52. A parasitic virus disease was introduced to Australia to control the rabbit population. What was the effect in the ecosystem?

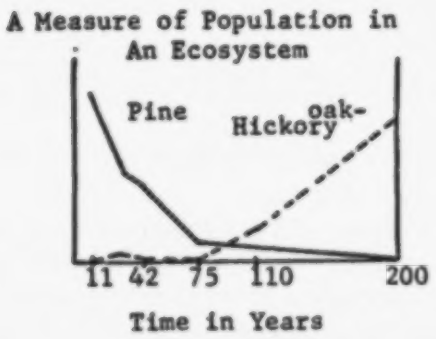
A. The populations of cattle decreased.
B. The biomass production of the grasses increased.
C. The populations of rabbits increased to the limits of their food supply.
D. All the populations decreased except that of the parasitic virus.

53. Suppose all the rabbits in Australia were killed by the virus disease. Then you would expect that

A. the virus population would die or lie dormant.
B. the virus population would increase.
C. the cattle population would die.
D. the cattle would destroy the biomass production of the grasses.

54. The sea lamprey is parasitic to fish. When the lamprey was accidentally imported into the Great Lakes ecosystems, the fish population there

A. increased to the limits of their food supply.
B. decreased.
C. was destroyed.
D. was not affected.



55. According to the graph,

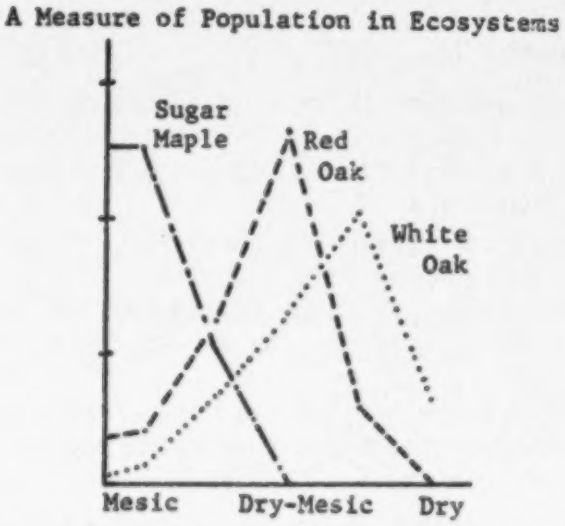
A. oak and pine trees are never associated in the ecosystem at the same time.
B. oak and hickory trees are never associated in the ecosystem at the same time.
C. pine trees succeed oak trees over time.
D. oak trees succeed pine trees over time.

56. Oak trees form the canopy of a deciduous forest and maple samplings form the understory. In this ecosystem it is likely that

A. maple will succeed oak.
B. oak will succeed maple.
C. a condition of equilibrium over time will exist for both populations of maple and oak.
D. a condition of equilibrium will exist between populations of maple and oak.

57. Which of the following tendencies of succession in land ecosystems is similar to the tendencies of eutrophication in water ecosystems?

A. Toward diversity in populations.
B. Toward diversity in microclimates.
C. Toward more efficient use of abiotic factors.
D. Toward an increasing amount of organic matter in the system.



58. A forest population consisting of red oaks that form the canopy and sugar maples that form the understory exists along a moisture gradient as indicated by the graph. Which of the following are reasonable predictions?

A. The red oak will succeed the sugar maple in the forest.
B. The white oak will succeed the red oak in the forest.
C. The forest floor will become wetter as succession proceeds.
D. The forest will become more useable as a place to graze cattle.

59. Water once passed through some marshlands into a lake. Now the marshlands have been drained. These marshlands once trapped the mineral salts that were dissolved in the water draining from the surrounding farmland. Also raw or partly treated sewage was deposited in the lake. What would you expect to occur?

A. An increased rate of eutrophication.
B. A decreased rate of algae growth.
C. A decreased rate of decomposition.
D. A decreased rate of sedimentation filling up the lake.

60. Chemicals are needed in modern agriculture to control populations of parasites, insects, and weeds. Often the chmicals wash from the farmlands into lakes. Population in these lakes will become smaller more rapidly

A. since these chemicals cause a decrease in the rate of eutrophication.
B. when the amount of water flowing *through* the lakes increases.
C. when the chemical has a low rate of biodegradability.
D. when the concentration of the chemical in the lake water is smaller.

TEST STATISTICS, PRETEST AND POSTTEST

	$\bar{X}$	s	R
Pretest	19.14	5.20	.60
Posttest			
Attainment Event	22.34	8.29	.82
Knowledge	8.44	3.43	.64
Comprehension	7.10	3.19	.60
Application	6.80	3.03	.57
Retention Event	21.08	8.34	.83
Knowledge	7.68	3.47	.66
Comprehension	6.66	3.26	.63
Application	6.74	2.98	.56
Pretest Concepts I	4.76	1.84	.48
II	2.89	1.55	.24
III	3.10	1.34	.05
IV	3.07	1.49	.18
V	3.06	1.60	.27
VI	2.26	1.33	.09
Posttest Concepts			
Attainment Event II	5.89	2.53	.50
III	6.71	2.92	.57
IV	4.63	2.35	.57
V	1.04	.93	.34
VI	4.08	2.33	.58
Retention Event II	5.48	2.42	.46
III	6.47	2.95	.58
IV	4.14	2.23	.53
V	.96	.90	.31
VI	4.03	2.18	.52

ITEM STATISTICS: POSTTEST

KNOWLEDGE LEVEL

Item No.	X_{50}	Proportion of each choice (underscore indicates correct choice) β	A	B	C	D	Omit
1.	.45	.48	.17	.23	.18	<u>.42</u>	.00
2.	.74	.33	<u>.41</u>	.14	.13	.32	.00
3.	-.05	.77	.08	<u>.51</u>	.25	.16	.00
4.	.51	.56	.19	.25	<u>.40</u>	.16	.00
13.	-.05	.58	<u>.51</u>	.09	.22	.18	.00
14.	-.10	.90	.10	.20	.17	<u>.53</u>	.00
15.	.56	.33	.20	<u>.43</u>	.20	.17	.00
16.	1.61	.57	<u>.21</u>	.15	.24	.38	.02
25.	-.49	.66	.19	<u>.61</u>	.13	.07	.00
26.	.91	.35	.28	.16	<u>.38</u>	.18	.00
27.	2.43	.21	.34	.26	<u>.31</u>	.09	.00
28.	.76	.40	.27	<u>.39</u>	.10	.23	.01
37.	1.01	.39	.33	.19	.11	<u>.36</u>	.01
38.	-.18	.53	.15	.14	.17	<u>.53</u>	.01
39.	.31	.74	<u>.43</u>	.20	.17	.19	.01
40.	-.83	.48	.17	<u>.64</u>	.11	.07	.01
49.	3.67	.27	<u>.17</u>	.19	.32	.27	.05
50.	.78	.71	.21	.22	.19	<u>.33</u>	.05
51.	-.19	.84	.12	.16	<u>.55</u>	.12	.05
52.	.85	.53	.13	<u>.34</u>	.20	.26	.07

COMPREHENSION LEVEL

Item No.	X_{50}	Proportion of each choice β	A	B	C	D	Omit
5.	5.49	.13	.15	.44	<u>.23</u>	.17	.01
6.	1.74	.41	.17	<u>.26</u>	.36	.21	.00
7.	1.83	.38	.38	.17	.19	<u>.26</u>	.00
8.	.31	.42	.30	<u>.45</u>	.15	.10	.00
17.	1.10	.41	.12	.21	.33	<u>.34</u>	.00
18.	.34	.64	.26	.16	.15	<u>.43</u>	.00
19.	.93	.49	<u>.34</u>	.12	.24	.29	.01
20.	1.66	.46	.16	.14	<u>.24</u>	.45	.01
29.	1.09	.47	.13	.33	.21	<u>.32</u>	.01
30.	1.39	.33	.25	<u>.33</u>	.23	.17	.02
31.	2.30	.34	<u>.23</u>	.30	.33	.13	.01
32.	.61	.48	.22	.16	.21	<u>.40</u>	.01
41.	.37	.77	.13	.19	.25	<u>.41</u>	.02
42.	.85	.55	.24	.12	<u>.34</u>	.28	.02
43.	.88	.58	.18	.19	.28	<u>.33</u>	.02
44.	-.24	.64	.17	.17	.08	<u>.55</u>	.03
53.	.05	.67	<u>.49</u>	.15	.14	.17	.05
54.	-.00	.46	.13	<u>.50</u>	.17	.14	.06
55.	.54	.85	.13	.14	.30	<u>.36</u>	.07
56.	1.25	.51	<u>.29</u>	.27	.18	.19	.07

APPLICATION LEVEL

Item No.	X_{50}	β	Proportion of each choice A	B	C	D	Omit
9.	.15	.69	.17	<u>.47</u>	.18	.18	.00
10.	.05	.60	.08	<u>.49</u>	.20	.22	.01
11:	2.17	.34	<u>.25</u>	.38	.23	.14	.00
12.	-.39	.50	.08	.14	<u>.57</u>	.21	.00
21.	9.03	.06	.17	.40	<u>.30</u>	.12	.01
22.	.17	.85	.19	<u>.46</u>	.13	.22	.00
23.	1.18	.45	.24	.30	<u>.32</u>	.14	.00
24.	.99	.75	<u>.27</u>	.24	.22	.27	.00
33.	.12	.75	.15	.18	.19	<u>.47</u>	.01
34.	-.49	.66	.08	.11	<u>.61</u>	.19	.01
35.	1.45	.49	.25	<u>.26</u>	.33	.15	.01
36.	1.19	.64	<u>.26</u>	.23	.36	.15	.00
45.	1.85	.40	.13	<u>.25</u>	.30	.29	.03
46.	48.65	.02	<u>.19</u>	.33	.25	.19	.04
47.	1.12	.72	.24	.27	<u>.26</u>	.19	.04
48.	.85	.49	.11	.29	<u>.35</u>	.20	.05
57.	1.74	.47	.17	.22	.30	<u>.23</u>	.08
58.	5.42	.14	.26	.25	<u>.22</u>	.18	.09
59.	.76	.63	<u>.34</u>	.18	.18	.21	.09
60.	2.22	.29	.25	.20	<u>.27</u>	.19	.09

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